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February 24, 2017

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: *Ex parte* presentation in IB Docket No. 11-109; RM-11681; IBFS File Nos. SES-MOD-20151231-00981, SAT-MOD-20151231-00090, and SAT-MOD-20151231-00091

Dear Ms. Dortch:

On February 22, 2017, Valerie Green, Executive Vice President and Chief Legal Officer of Ligado Networks LLC ("Ligado") and the undersigned met with Ron Repasi, Michael Ha, and Paul Murray of the Office of Engineering and Technology; Charles Mathias, Paul Powell, and Aalok Mehta of the Wireless Telecommunications Bureau; Jennifer Tatel of the Office of General Counsel; and Bob Nelson of the International Bureau. The purpose of the meeting was to discuss both Ligado's process in working with the FAA and the final report by the National Advanced Spectrum and Communications Test Network ("NASCTN") on the impacts of mid-band LTE signals on GPS receivers.

Aviation Update: We discussed that Ligado's 2015 license modification applications requested a license condition that would require Ligado to reduce the power of its transmitters operating in the 1526-1536 MHz band to whatever power level may be necessary to comply with certified aviation GPS standards. For more than a year since its FCC applications were filed, Ligado has worked diligently with the FAA and the agency's advisory panels to implement this proposal. The results of Ligado's extensive work with the FAA were submitted to the agency's advisory panel, the RTCA, in September 2016. The RTCA provided comments to the FAA in December 2016. These comments show that all remaining issues are well within the FAA's ability to resolve.

Ligado is now preparing to discuss with all of the relevant regulatory agencies the specific provisions of the condition. We discussed the three elements of the condition. First, Ligado would be required to limit its transmit Equivalent Isotropically Radiated Power ("EIRP") levels in the 1526-1536 MHz band to the lower of:

(a) 32 dBW on a nationwide basis, *or*

(b) for each Ligado base station the limit that would be calculated for such base station using models developed with the FAA.[1]

Second, Ligado would be required to publish the results of its calculations before it begins operations. Third, Ligado would be required to develop a system to monitor and respond to any complaints.

NASCTN Report: We then discussed the NASCTN report, a Government study conducted by the research center jointly run by the U.S. Department of Defense and Department of Commerce and housed at NIST's facilities in Boulder, Colorado.[2] This comprehensive 428-page study that involved 1,476 hours of testing validates the conclusion reached by the major GPS companies over the last 14 months: An LTE network operating within the specifications proposed in Ligado's pending FCC applications will not harm the performance of GPS devices.

We observed that the test results in the Government study found no impact on the position and timing accuracy of many GPS devices when exposed to mid-band LTE signals at significantly higher power than they would be under Ligado's proposal, as illustrated on pages 128 and 191 of the Government study. In addition, the results reported by NASCTN demonstrate that a simple antenna change can eliminate any impact Ligado's proposal might have on high-precision positioning devices. We discussed the attached charts from the report and how they, and dozens and dozens of other charts throughout the study, illustrate that the study confirms Ligado's prior submission in the record that that a 1 dB-Hz decrease in the carrier-to-noise-density ratio (C/N_0) is not the appropriate standard for assessing harm to GPS receivers.

We concluded by saying that, considering our progress with the FAA and the results of the NASCTN report, the Commission now has the information it needs to make this 35 megahertz of vital mid-band spectrum available to serve America's infrastructure needs.

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[1] *See* Letter from Gerard J. Waldron, Counsel to New LightSquared LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, IB Docket No. 12-340; IB Docket No. 11-109; 12-340; IBFS File Nos. SAT-MOD-20120928-00160; SAT-MOD-20120928-00161; SES-MOD-20121001-00872, at 3-4 (Dec. 31, 2015) ("Modification Applications Cover Letter"); IBFS File Nos. SAT-MOD-20151231-00090, SAT-MOD-20151231-00091, and SES-MOD-20151231-00981, Description of Proposed Modification and Public Interest Statement at 6-7 (Dec. 31, 2015) ("Modification Applications").

[2] William F. Young et al., *LTE Impacts on GPS Final Report*, NASCTN (Feb. 15, 2017), http://nvlpubs.nist.gov/nistpubs/TechnicalNotes/NIST.TN.1952.pdf.

Please direct any questions to the undersigned.

Sincerely,

/s/ Gerard J. Waldron
Gerard J. Waldron
Brian Smith
Dustin Cho
Counsel to Ligado Networks LLC

Attachments

cc: Mr. Charles Mathias
Mr. Bob Nelson
Mr. Paul Murray
Mr. Michael Ha
Ms. Jennifer Tatel
Mr. Ron Repasi
Mr. Paul Powell
Mr. Aalok Mehta

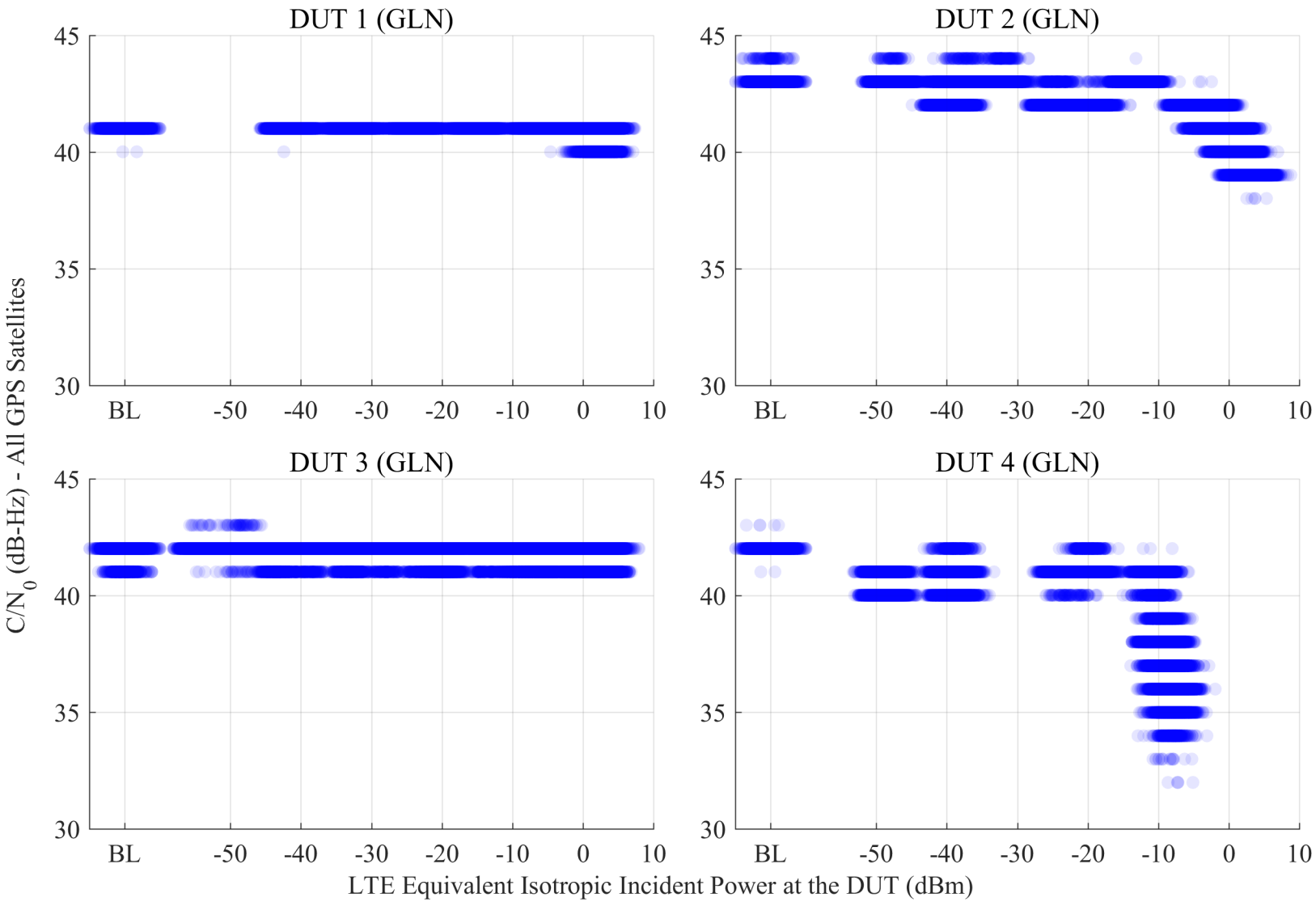

Figure 6.4: Scatterplots of reported C/N_0 from GLN receivers, swept with LTE power level. The GPS scenario is nominal, and the type of incident LTE is DL.

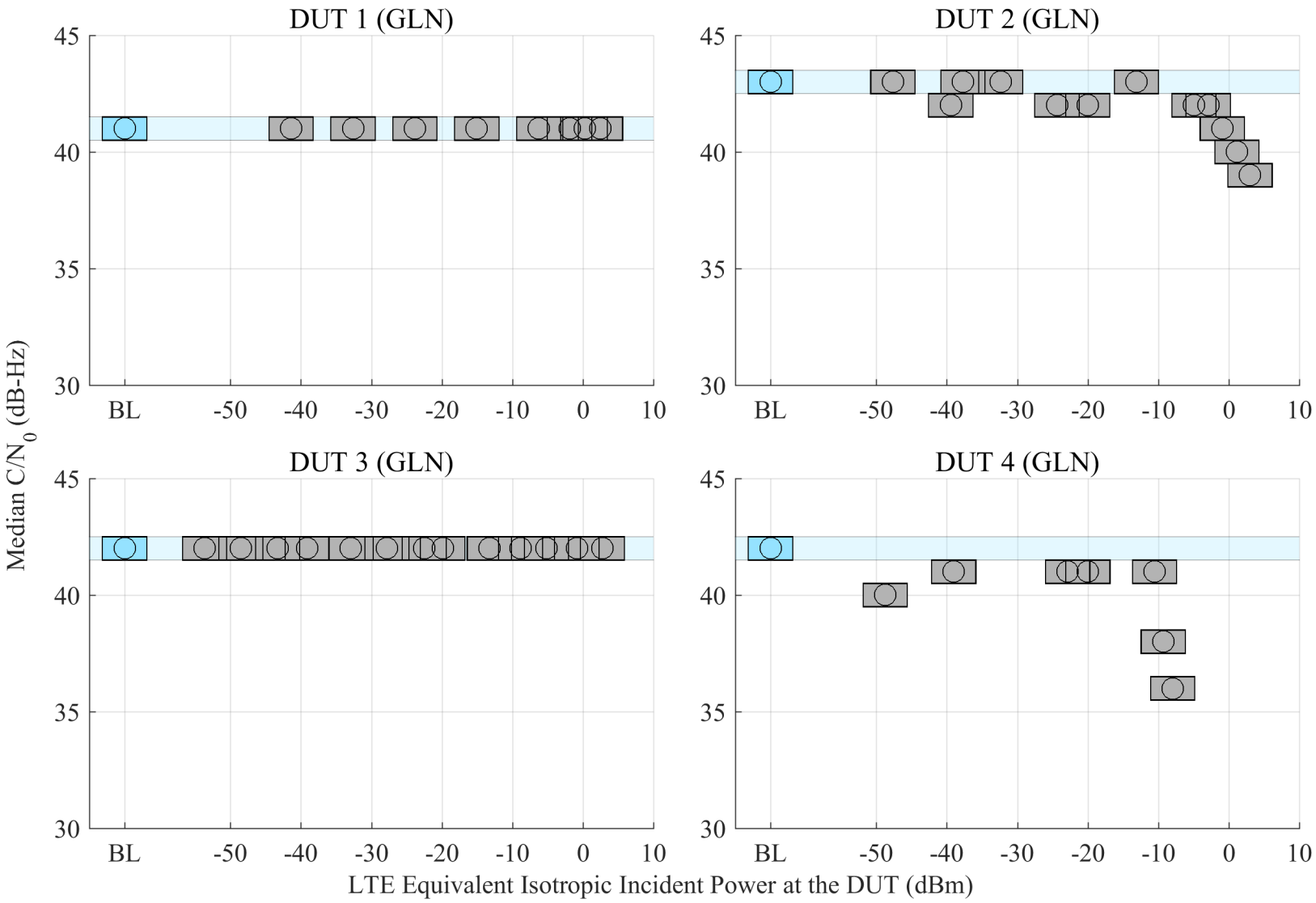

Figure 6.5: Estimated 95% confidence regions of the median of reported C/N_0 from GLN receivers, swept with LTE power level. The GPS scenario is nominal, and the type of incident LTE is DL.

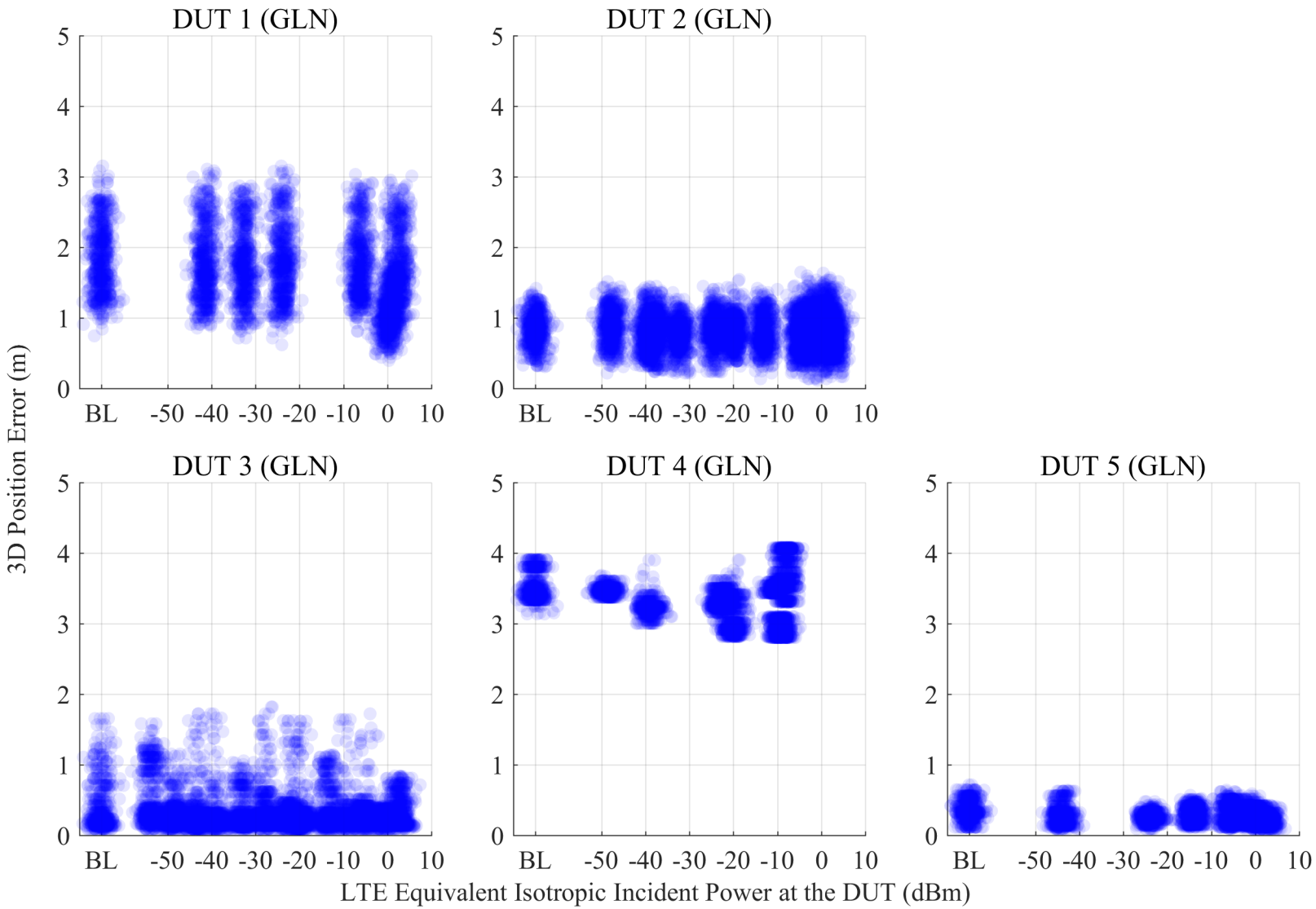

Figure 6.6: Scatterplots of error in reported 3-D position compared to simulator truth from GLN receivers, swept with LTE power level. The GPS scenario is nominal, and the type of incident LTE is DL.

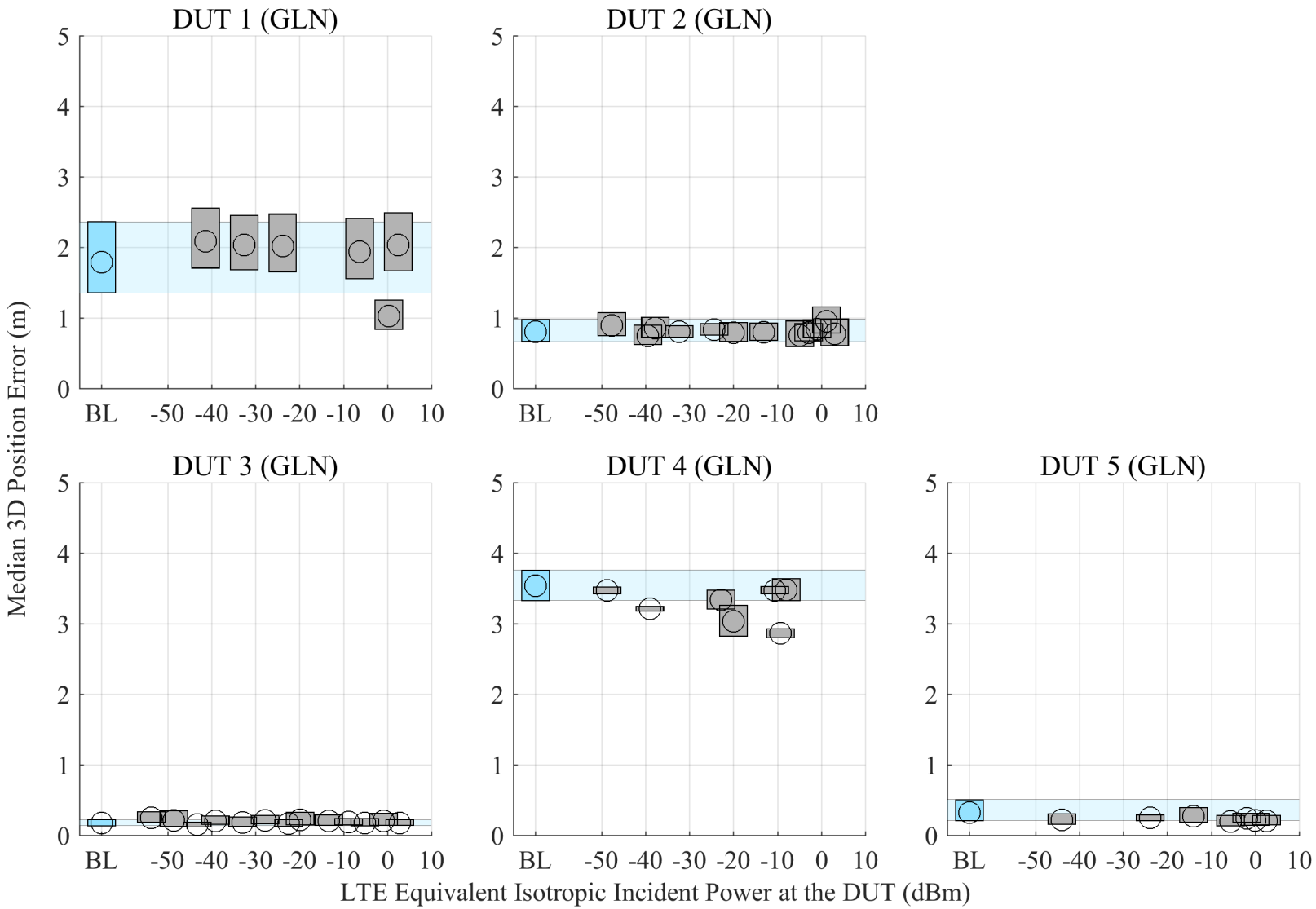

Figure 6.7: Estimated 95% confidence regions of the median error in reported 3-D position from GLN receivers, swept with LTE power level. The GPS scenario is nominal, and the type of incident LTE is DL.

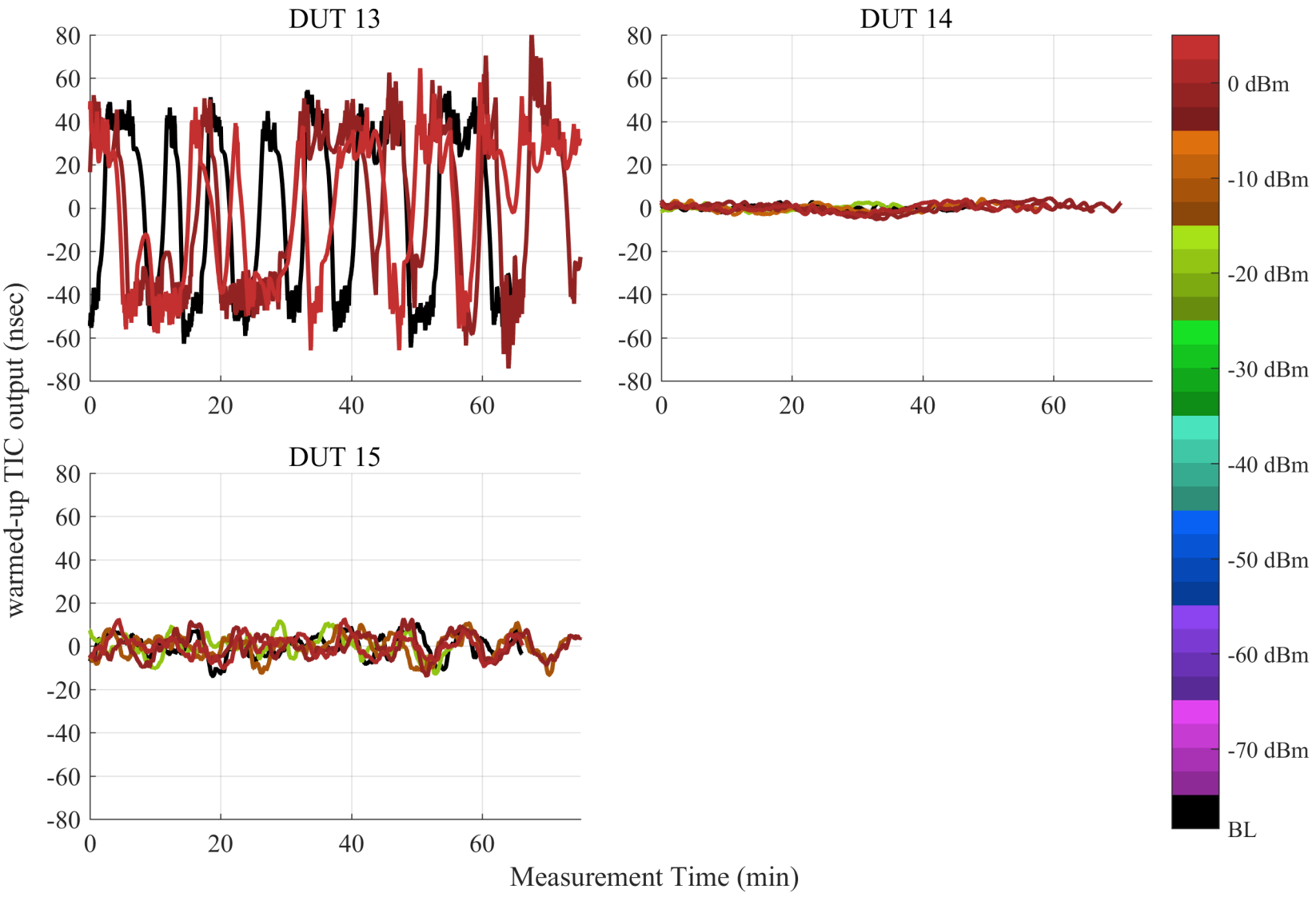

Figure 6.69: Plots of stability of 1 PPS output of a GPSDO receiver measured against that of the GPS simulator from GPSDO receivers, swept with LTE power level. The GPS scenario is timing, and the type of incident LTE is DL.

B.3 Results

Figures B.1 and B.2 contain histograms for the five C/N_0 estimators under AWGN and Rician GPS channels, respectively.

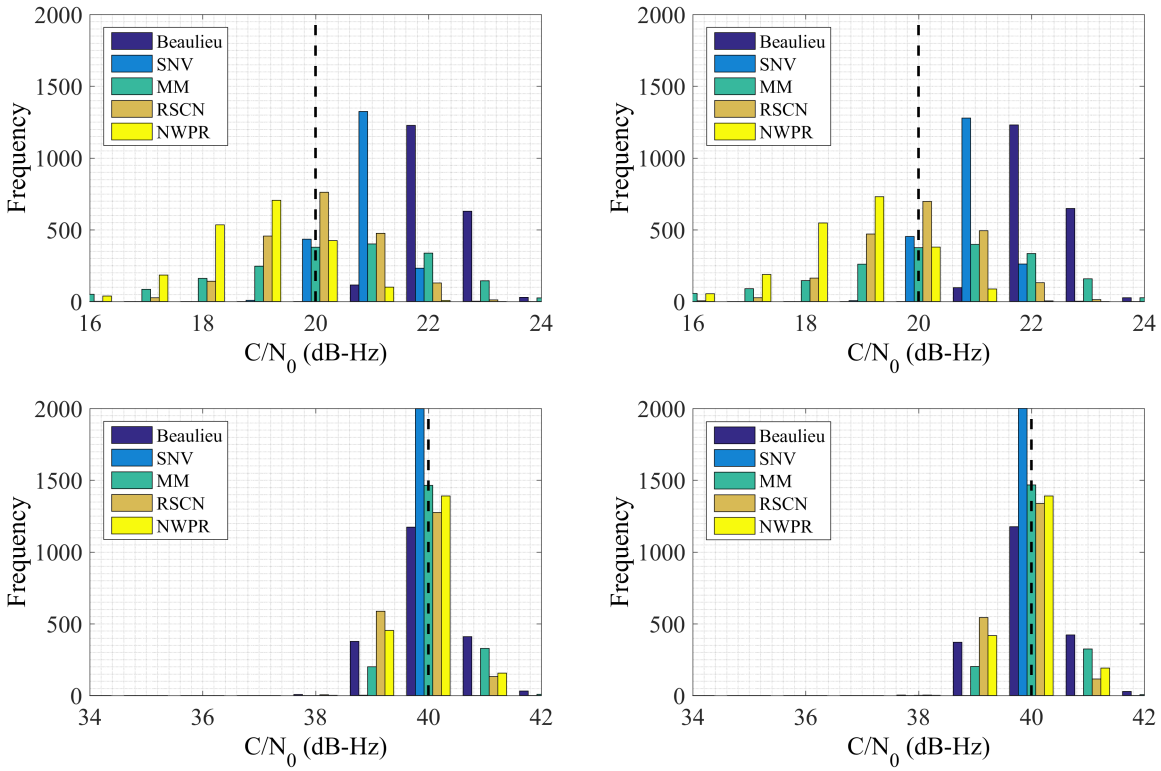

Figure B.1: Histograms of C/N_0 estimates with an AWGN GPS channel. Top: true C/N_0 = 20 dB-Hz, Bottom: true C/N_0= 40 dB-Hz. The LTE power at the plane of DUT is -20 dBm (Left) and -40 dBm (Right). The vertical dashed line indicates the true C/N_0 value.

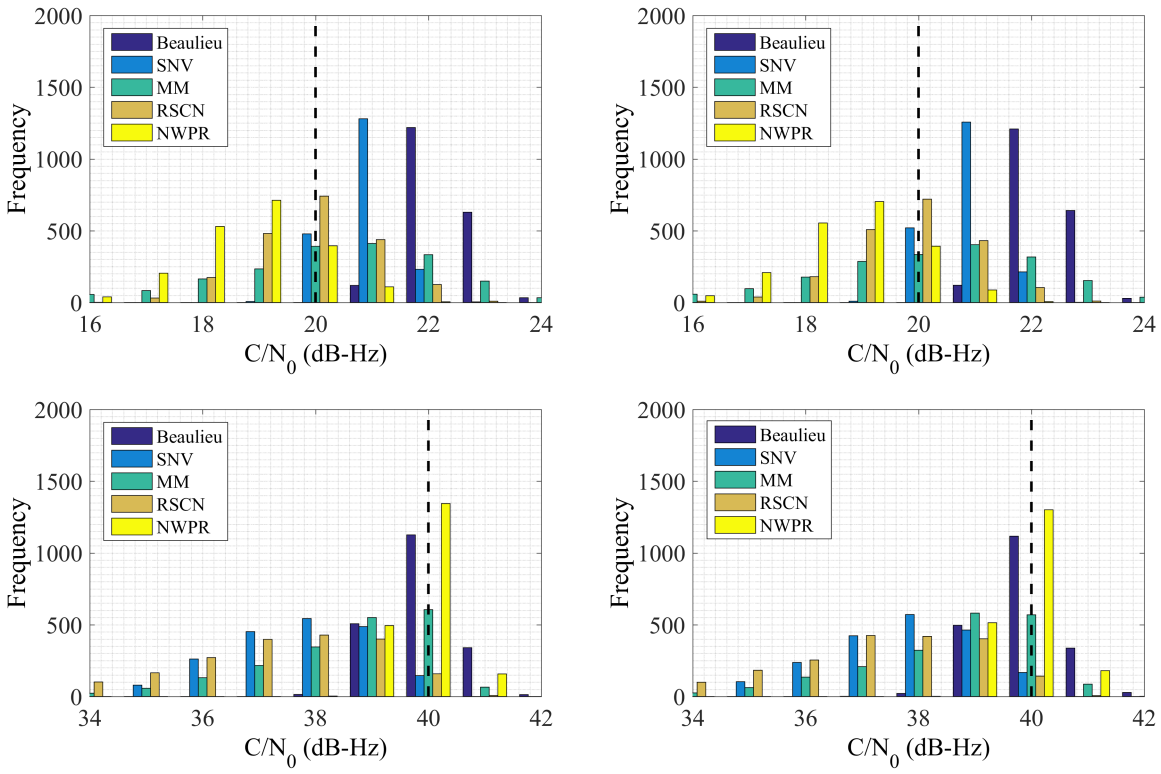

Figure B.2: Histograms of C/N_0 estimates with a Rician GPS channel. Top: true C/N_0 = 20 dB-Hz, Bottom: true C/N_0 = 40 dB-Hz. The LTE power at the plane of DUT is -20 dBm (Left) and -40 dBm (Right). The vertical dashed line indicates the true C/N_0 value.

B.4 Summary

The limited results presented here indicate that under some conditions, there may be differences between distributions of C/N_0 estimators. Such differences would indicate variations that could be expected due to the choice of an C/N_0 estimation algorithm. However, note that the results shown here are preliminary, and do not warrant strong conclusions, which would require a more thorough investigation. This evaluation of C/N_0 estimation algorithms included some features that may be important to consider in future investigations, such as

- a fading GPS channel,
- modeling the effect of in-band and out-of-band LTE signals,
- computing the impact of LTE on the GPS receiver correlator using actual C/A PRN codes, and
- imperfect carrier tracking loop and Doppler shift estimation.